Compression members with slender Class 4 box sections susceptible to combined local and global buckling for use in steel arch bridges

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Summary

This paper presents the results of a research project analysing some aspects of stability failure of thin-walled compression members likely to exhibit combined global and local buckling. In particular, the influence of various imperfections (namely residual stresses due to welding and local as well as global geometrical defects) on the load-carrying capacity was subject to detailed experimental and numerical investigations. The insight into the structural behaviour lead to a modification of the non-dimensional slenderness used in the global buckling verification and to the recommendation of a shift from the currently applied European buckling curve to a more favourable one in the case of non-stiffened members with welded box sections subjected to pure compression.

Keywords: Thin-walled compression members, coupled instabilities, design curves, arch bridges

1. Introduction

The design of steel and composite bridges is often determined by a wish for slender lightweight structures due to transportation reasons or high demand on aesthetics. For these structures, the use of high-strength steel in combination with thin plates is highly advantageous. Thin plates are used for plated beam structures as well as for arches or bars of truss girders. In these last two cases (arches and truss), the plates are welded together to rectangular cross sections and usually not stiffened by longitudinal stiffeners in order to avoid welding costs where possible.

For steel arches and truss structural elements, the overall dimensions of the cross section are essentially governed by the overall stability problem and may thus not be reduced under certain values. As a consequence, especially for high steel grades with small limits of width-to-thickness b/t ratios, it becomes difficult to keep a cross section classified as class 3 and to avoid therefore any reduction of the resistance due to local plate buckling. As welding of stiffeners inside the box is nowadays usually uneconomic, the section of the plated box girder has thus to be designed as slender class-4 section and interaction of global and local buckling has to be considered. The overall member buckling is coupled with the local plate buckling and account has to be taken for both sources of reduction of the load bearing capacity. Figure 1 schematically shows the principles of this interaction of local and global instability failure.

In practice, even in the case of thin-walled members, the global buckling problem is treated with the well-known European buckling curves, which were developed in the 1970's [1]. The design procedure of the latest Eurocode version EN 1993-1-1 and EN 1993-1-5 [12, 13] recommends the use of a modified non-dimensional global slenderness and of the buckling curve ***b***. On this basis, the verification of the buckling resistance may be carried on as for class 1 to 3 members.

https://doi.org/10.2749/222137807796120003
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